Appendix D

Increased CE-QUAL-W2 Algal Productivity

Increased algal Productivity in Lake Spokane

Soltero et al., (1993) collected phytoplankton data (biovolume, chlorphyll, species compsition) during June-October for three years, 1990-92. During each year a diatom bloom occurred in the summer succeded by a large blue-green bloom. They sampled every month during 1991 and reported a spring diatom bloom that peaked in May. In all study years the blue-green bloom was greatest in the upper end of the lake (see Figure 23), but started and peaked at different times probably due to differences in river flow and influent TP concentration. For example, the daily average flow, TP concentrations, peak chl *a*, and date of peak bloom are listed below in Table D1:

Table D1. Data from Soltero et al., (1993) for late summer-fall blue-green algal blooms and associated Spokane River flows and phosphorus concentrations.

Year	August-September Daily Average River Flow at Spokane (cfs)	August-September Average Spokane River Influent TP (ug/L)	Peak Euphotic Zone Average chl *a* Concentration at LL4 (ug/L)	Date of Peak chl *a*
1990	1577	25	71	9/24
1991	1522	21	73	10/7
1992	1012	27	106	9/14

Chl *a* samples collected at LL4 on August 29-30, 2001 were 70 ug/L at the surface, and 22 ug/L at 6 m depth (euphotic zone was estimated to be 5.4 meters depth, i.e., estimated depth at 1% of incident surface radiation.) In addition much more dense blue-green bloom was observed during the middle of September. However, the currently calibrated CE-QUAL-W2 model significantly underestimates productivity in the upper end of the lake during this period. For example, the chl *a* concentrations were only predicted to be 3-4 ug/L and algal biomass 0.4-0.5 g/m^3 throughout the euphotic zone from the middle of August through the middle of September.

In order to simulate the affects of the 2001 late summer-early fall blue-green algal bloom, the CE-QUAL-W2 model input file was modified to add a second algal group and decrease particulate organic mater (POM) settling rate to 0.01 m/day. The model control file was modified to add the algal group as follows:

ALGAL RATE	AG	AR	AE	AM	AS	AHSP	AHSN	AHSSI	ASAT
Alg 1	1.5	0.04	0.04	0.10	0.20	0.003	0.014	0.000	40.0
Alg 2	1.7	0.04	0.04	0.10	0.01	0.002	0.014	0.000	95.0

ALGAL TEMP	AT1	AT2	AT3	AT4	AK1	AK2	AK3	AK4
Alg 1	8.0	10.0	18.0	25.0	0.1	0.99	0.99	0.10
Alg 2	14.0	20.0	25.0	30.0	0.1	0.99	0.99	0.10

Figures D1 and D2 show the modified model predicted dissolved oxygen profiles versus the measured data for August 8 and 29, 2001. With the second algal group the model predicts higher August-October productivity than the currently calibrated model (current model). The measured and predicted profiles show good agreement, particularly in the upper end of the lake represented by sampling station LL3.

Figure D3 shows the difference between the CURRENT and NO-POINT scenario results for model segment188, 181, 178, and 168 for Julian day 258.25 with the higher August productivity. The maximum dissolved oxygen deficits were predicted to be 1.4 at segment 188 and 1.6 mg/L at 181 and 178. The results were slightly lower than the current model for segment 188 (deficit 1.6 with the current model) and higher for 181 and 178 (deficits were 1.4 with the current model.) However, with higher productivity segment 168 was predicted to have a maximum deficit of 2.9 mg/L, because internal loading of BOD was predicted to increase at the upper end of the lake. In addition, the time of maximum deficit was predicted to occur earlier (near the end of August) than with the calibrated model (middle of September). Figure D4 shows the model results for August 31 (Jday 243). All of the segments were predicted to have greater deficits than the calibrated model, except for 188 which again was predicted to have a slightly less deficit (1.2 versus 1.6 mg/L at segment 188). The maximum deficit was predicted to be 3.5 mg/L and occur around segment 168.

These results suggest that the currently calibrated CE-QUAL-W2 model is likely providing underestimates of the impacts of pollutants on dissolved oxygen in Lake Spokane.

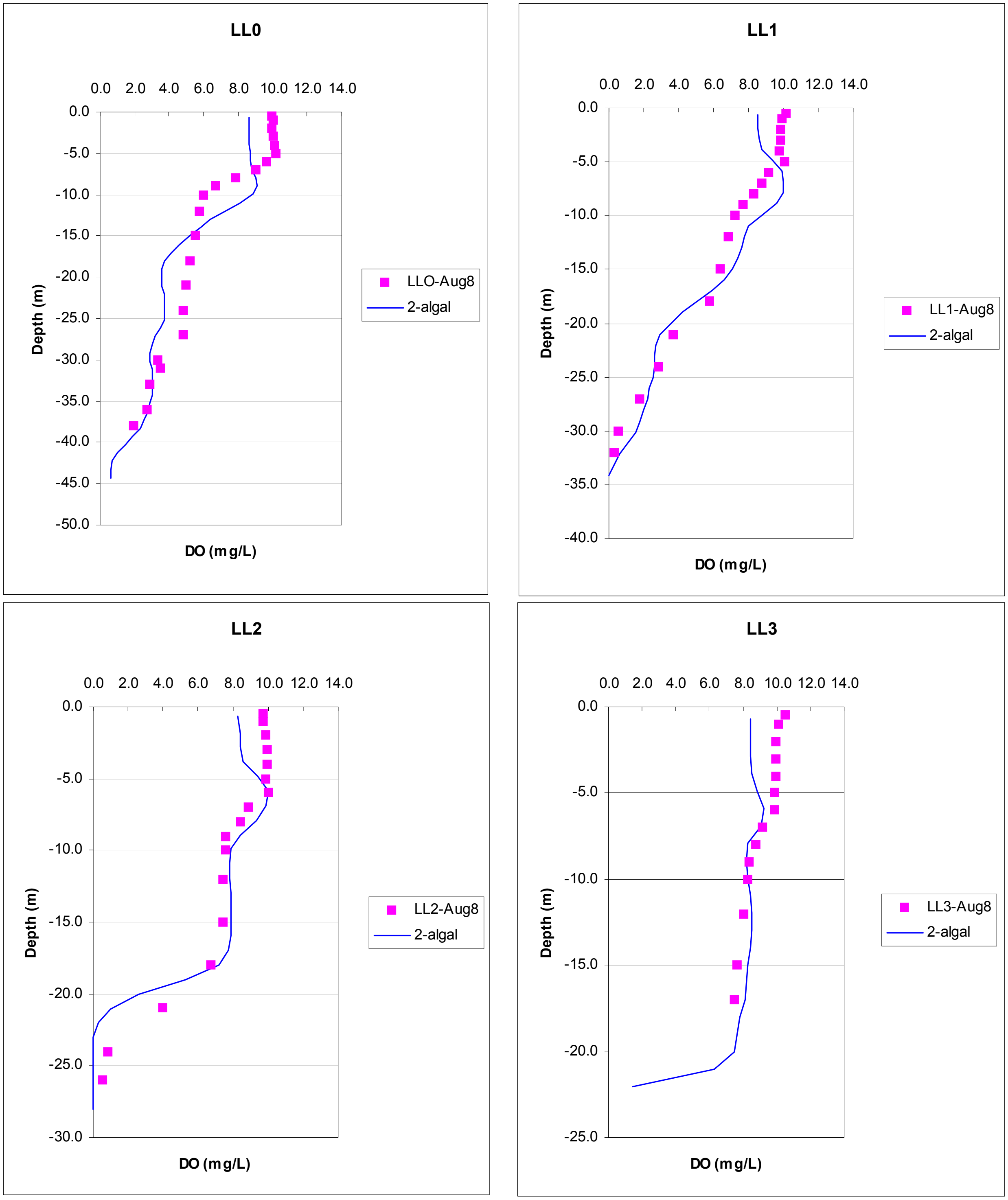

Figure D1. Model versus measured dissolved oxygen concentrations on August 8, 2001 with more algal productivity.

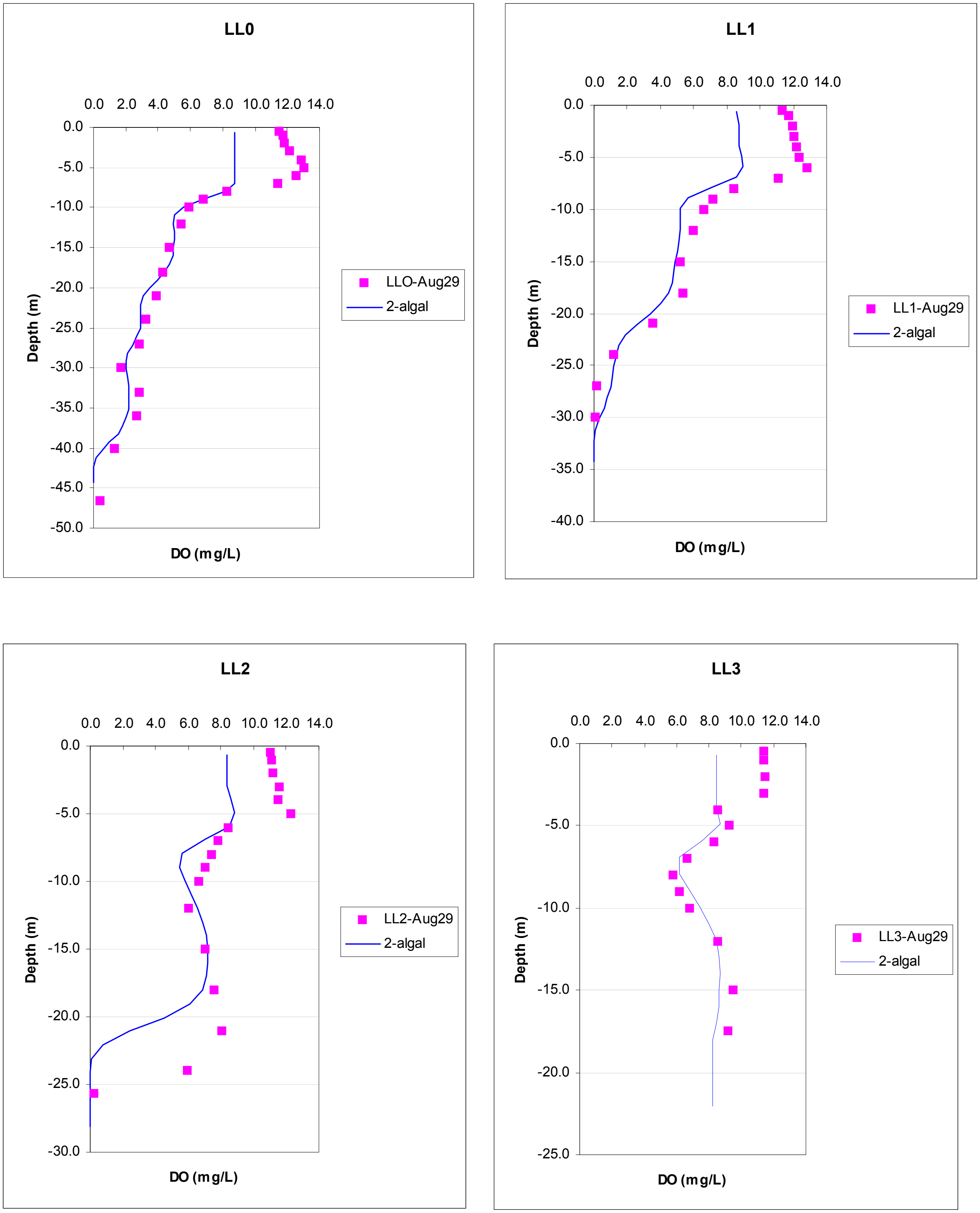

Figure D2. Model versus measured dissolved oxygen concentrations on August 29, 2001 with more algal productivity.

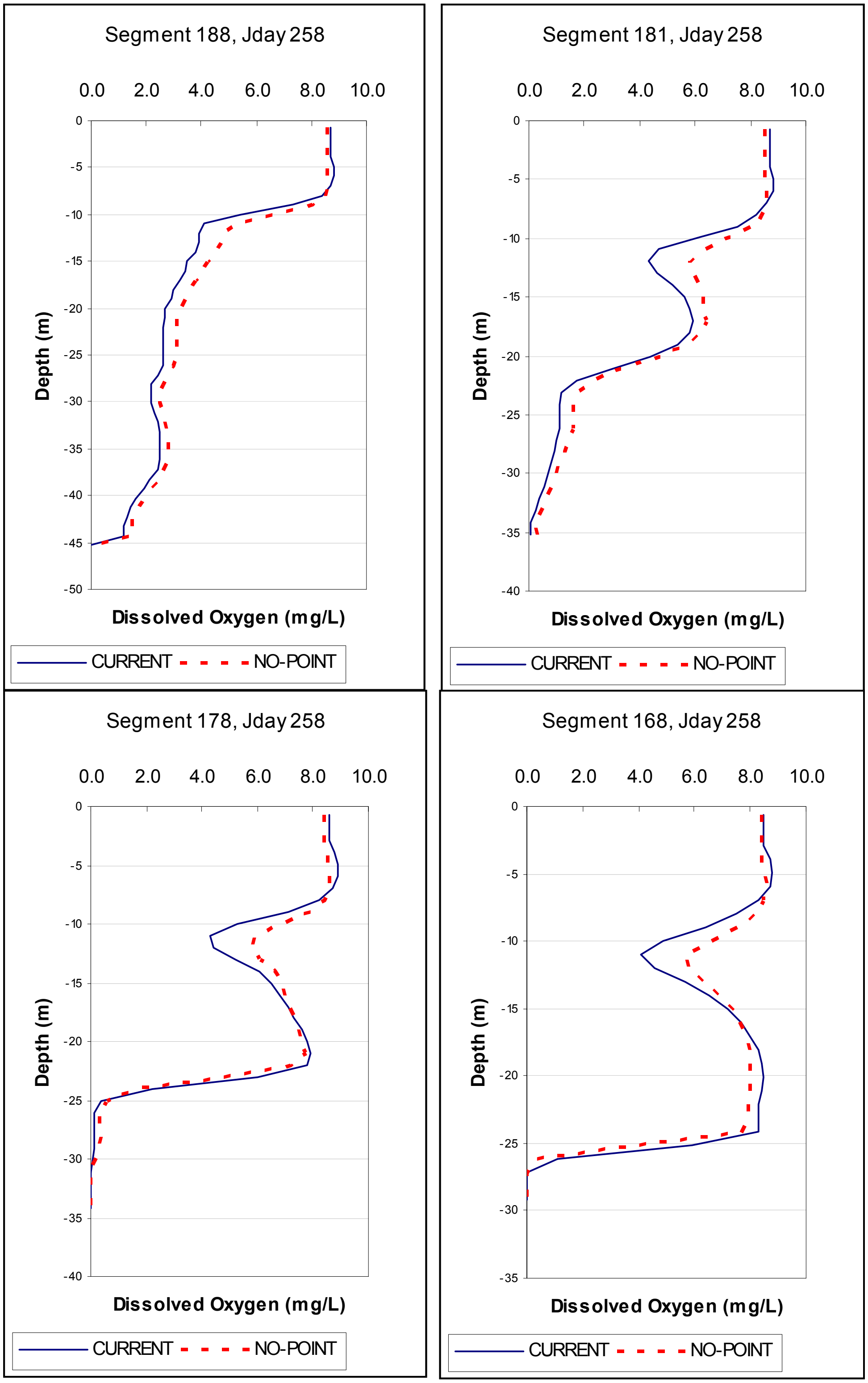

Figure D3. Model predicted dissolved oxygen profiles for Lake Spokane model segments 188, 181, 178, and 168 for the CURRENT and NO-SOURCE scenarios with higher algal productivity on Jday 258.

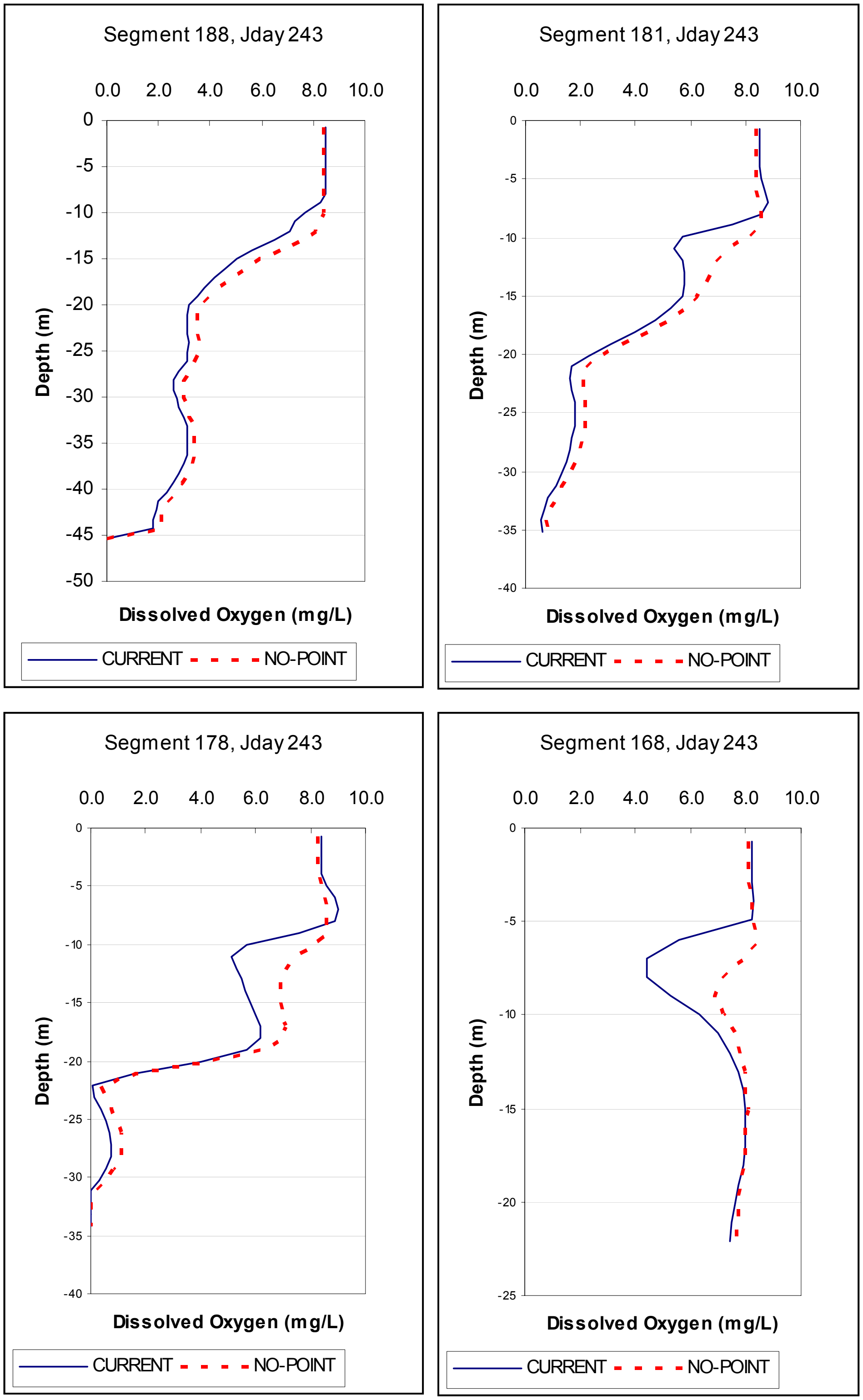

Figure D4. Model predicted dissolved oxygen profiles for Lake Spokane model segments 188, 181, 178, and 168 for the CURRENT and NO-SOURCE scenarios with higher algal productivity on Jday 243.